Drone RFID Iventory System

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DEVELOPMENT OF GRAPHICAL USER INTERFACE FOR DRONES VEHICLES IN WAREHOUSE INVENTORY MANAGEMENT SYSTEM

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ABSTRACT

This research introduces an innovative approach to enhance warehouse inventory management through unmanned aircraft technology. The study focuses on the development and testing of user-friendly graphical user interfaces (GUI) for the Unmanned Aircraft (UAV) Control Page and the Inventory Data Processing Page. The Unmanned Aircraft Control Page testing validated successful Unmanned Aircraft connections, Micro Air Vehicle Link to Robot Operating System (MAVROS) system activations, and data monitoring of Unmanned Aircraft status. Efficiency comparisons revealed significantly shorter flight preparation times with the GUI compared to conventional methods. Testing on the Inventory Data Processing Page ensured seamless functionality of data tables, database connections, and data export features. The results provide a robust assessment of interface reliability and quality. Statistical analysis confirmed the GUI's consistent superiority in reducing flight preparation times. These findings underscore the GUI's potential to enhance operational efficiency in UAVs dedicated to inventory tasks.

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1. INTRODUCTION

In recent times, there have been significant advancements in the inventory work system implemented within warehouses compared to previous periods. Numerous developers have tried optimising this system to enhance its performance and enable more efficient and precise inventory work and warehouse management. Despite these developments, the widespread adoption of the improved warehouse inventory work system remains uneven among companies across various regions[1]. Several instances have demonstrated that implementing these enhancements has not fully met the companies expectations or achieved their desired outcomes. One challenge in warehouse inventory work is the demand for enhanced mobility and flexibility in data scanning for stored goods. Warehouse shelves often have heights that are challenging for labour to reach, and they come in varying lengths, leading to delays in inventory work and the updating of item information [1], [2].

There is an imperative need to advance the warehouse inventory system to address the limitations associated with current manual inventory practices. The primary objective is to facilitate a shift towards automated inventory operations. The prevailing manual methods require significant labor input and consume substantial time, financial resources, and human resources. This study is committed to meeting the specific needs and preferences of companies that intend to adopt this innovative system [3].The proposed approach entails the integration of unmanned aircraft technology, offering superior capabilities compared to the labor-intensive manual inventory procedures. Furthermore, this technological integration is expected to yield substantial advantages in warehouse inventory, including cost efficiency, reduced processing time, and optimized allocation of human resources [3], [4].

In general, the successful operation of unmanned aerial vehicles (UAVs) demands a spacious and unobstructed environment, as any impediments can significantly compromise their flight capabilities. Operating UAVs entails a meticulous focus on security and safety measures to mitigate potential risks and hazards inherent to their operation. However, deploying UAVs within a warehouse setting introduces a multifaceted challenge [5], [6].Warehouses are characterized by constrained spaces filled with shelves of varying heights and widths, meticulously designed to accommodate diverse stock items. Consequently, formulating an efficient UAV control system suitable for warehouse deployment becomes complex. This complexity is further amplified by the anticipated users of such a system, who may need more familiarity with UAV technology [7] .

This scientific study activity aims to construct a control and communication system between software and hardware in the form of an unmanned aircraft. This control system is computer software sn the form of a graphical user interface capable of direct connection with an unmanned aircraft [8], [9]. This development will enable the deployment of autonomous aircraft in indoor flights or regions difficult to reach by humans. In addition, this control system will also allow users to control and monitor the unmanned aircraft in real-time using the user's computer device [10]. With this control system, users can easily define fly paths, control the aircraft's altitude, and collect data and information the unmanned aircraft provides for further analysis and monitoring of the flight's performance [11].

Nevertheless, there are many visual components in the form of graphical user interfaces circulating among users, but with complicated usage, consumers often need help understanding and utilizing these interfaces. It is also very unusual to design a graphical user interface program connected to unmanned aircraft use in a particular industry [12]. Therefore, this research intends to design a simpler and more user-friendly interface so that users can quickly understand and control unmanned aircraft according to user demand. In addition, designing a more user-friendly graphical user interface can help improve the efficiency and productivity of warehouse interior inventory operations. Thus, users can save the time and effort previously required to perform inventory manually [13]. Moreover, a simple and easy-to-use interface can lower the human error rate in performing inventory operations. With easy accessibility and usability, users can easily identify and track items within the warehouse, thus limiting potential errors in entering and classifying inventory.

2. METHOD

2.1 System Design

To fulfill the specified requirements, the system demands the harmonious integration of diverse hardware components, encompassing personal computers, routers, mini PCs, flight controllers, cameras, and additional sensors. Simultaneously, the effective utilization of software is imperative to seamlessly integrate and process these diverse hardware components[14].

Hardware Components

Table 1 outlines the key hardware components integral to the system's functionality, ranging from personal computers and mini PCs to flight controllers and sensors. The inclusion of the Intel RealSense T265 camera enhances the system's capabilities for precise localization.

Table 1. Hardware Components

Item	Description
PC/ Personal	- CPU: Core i3 - Memory: 4GB - OS: Ubuntu - SSD: 120 GB
Raspberry Pi 4(Mini PC)	- Broadcom BCM2711 - Quad Core C-A72 - 8GB LPDDR4-3200 - 2.4 GHz and 5.0 GHz
Router Asus RT-AC59U	- 2.4GHz and 5GHz. - WPA/WPA2 - Wi-Fi 802.11ac (Wi-Fi 5)
Pixhawk Cube Orange	- 600 MHz - Support Ardupilot and PX4
Intel RealSense T265	- Time-of-Flight (ToF) sensor - Gyroscope: 6 axes - Accelerometer: 6 axes - Voltage: 4.5 - 5.5 V DC

Software Integration

In tailoring the software integration, a fundamental focus has been placed on user-friendliness, especially catering to individuals with limited UAV knowledge. The software framework is intentionally designed for simplicity, incorporating specific features aimed at enhancing user guidance within the graphical user interface (GUI).

The User Interface (UI) design prioritizes visual clarity, ensuring a clean and uncluttered layout that facilitates easy navigation for users. This emphasis on an intuitive design extends to the inclusion of user-friendly elements, contributing to an overall enhanced user experience. Additionally, specific widgets have been integrated into the UI to provide users with guidance, offering clear instructions and clarifications.

By seamlessly integrating these features, with a particular highlight on tooltips and dedicated widgets, the software seeks to elevate user understanding and interaction. This strategic approach ensures that individuals, irrespective of their familiarity with UAV technology, can navigate and manage the system for warehouse inventory tasks with confidence. The overarching goal is to cultivate a user-friendly and supportive environment, promoting effective utilization of the system[15][16].

User Interface Overview

Figure 1 below provides a comprehensive overview of the graphical user interface (GUI) for inventory tasks. Notably, the communication between the GUI and the underlying system occurs through a remote network protocol. In this setup, the mini PC onboard the UAV serves as a server responsible for data provision and storage, while the user's PC functions as a secure and encrypted client. The GUI undergoes authentication as a client, enabling it to manage and store data both on the server and the client itself securely[17].

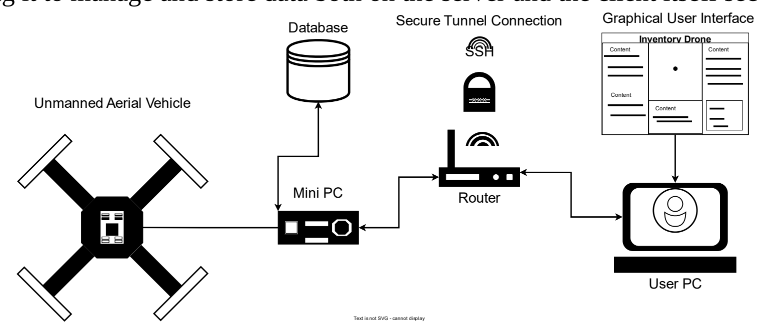

Figure 1. User Interface System Overview

In terms of the networking protocol, the communication flow between the GUI and the server is facilitated by a remote network protocol. This particular setup ensures the transmission of data between the UAV's mini PC, acting as the server, and the user's PC, operating as the client, is secure and encrypted.

Simultaneously, an authentication mechanism is implemented within the graphical user interface. This robust authentication process validates the GUI's identity as a client, thereby authorizing it to perform data management and storage activities securely on both the server and the client. This strategic approach enhances the overall security posture of the system, safeguarding the integrity of data throughout the communication process.

2.2 User Interface System

Within the development of this system, the user interface stands out as a pivotal component, and this interface is executed using the PyQT5 library and the Python programming language for handling background functionalities within the application. The user interface is also meticulously designed, focusing on responsiveness and user-friendly principles, ensuring an effortless user interaction with the system. Through the integration of PyQT5 and Python, this system can provide adaptable and valuable functionalities, thereby enhancing the user experience[18].

The PyQT5 library is a link between the python programming language and the graphical user interface developed by QT, this library is basically used to create a graphical user interface with the use of available windows and can be through the classes of the PyQT5 library The most important and basic component of this library is the use of signals and slots, Because this library requires an event or action performed by the user so that the function or method of the program created can run according to the desired action, the user must add a signal and slot to each window that will be used, because each window used from this library will emit a signal, and each signal will be connected to a slot where the use of the slot can be called on the function or method created in the graphical user interface[19].

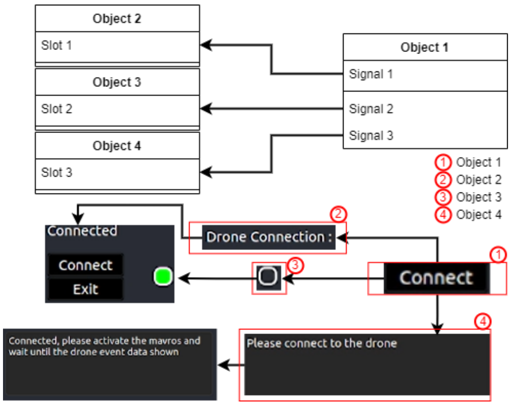

Figure 2. Illustration of Signal and Slot

The figure 2 above shows a concrete illustration of some examples of PyQT5's application to graphical interfaces, where each element, represented as an object, is closely related through the concept of signals and slots. There are four objects visible in the image, each with a specific role.

Object 1, which represents a widget for performing connection actions to the Unmanned Aircraft in the interface, is seen to have three unique signals, namely signal 1, signal 2, and signal 3. These signals serve as triggers for interface interactions, signaling status changes or certain events. Object 2 plays the role of an action receiver by providing a slot, slot 1, which is linked to the correspondent signal from Object 1. As such, Object 2 is responsive to state changes or events originating from Object 1. Object 3 and Object 4, also as widgets on the interface, have slot2 and slot3 respectively. As with Object 2, the linkage between the signals in Object 1 and the slots in Object 3 and Object 4 creates a coherent and interacting relationship between these objects.

Through the implementation of signals and slots, each widget or object on the interface can communicate efficiently, ensuring proper response to user actions or changes in circumstances. As such, this concept becomes a key cornerstone in building a dynamic, adaptive, and responsive interface, in accordance with modern design principles that prioritize optimal user experience. The successful implementation of this method confirms the reliability of the application and the effectiveness of the integration between the components that make up the graphical user interface.

2.3 Communication and Control System

The Communication and Control System is integral to the warehouse Unmanned Aircraft operations, utilizing a sophisticated graphical user interface (GUI) to address inventory management challenges. This section focuses on the central role of the Mavros communication protocol and introduces the SSH connectivity for interfacing with the UAV's mini PC[20].

Mavros Protocol

The GUI is specifically tailored for warehouse inventory management, leveraging the Mavros communication protocol to facilitate seamless interaction between the GUI and the Unmanned Aircraft's flight control system. Mavros serves as an efficacious bridge, enabling the Unmanned Aircraft to execute actions based on user commands with efficiency. Mavros (Mavlink to ROS), represents an intelligent communication protocol. In contrast to the manual data handling inherent in Mavlink, Mavros streamlines the communication process, providing a more efficient approach to command execution[21][22].

SSH Connection to UAV's Mini PC

In addition to the Mavros protocol, the GUI establishes an SSH connection to the mini PC embedded on the UAV. This SSH link is instrumental in executing various tasks, including the activation of Mavros functionalities and UAV flight plan formulation. The SSH connection establishes a secure and authenticated link between the GUI and the mini PC, facilitating the transmission of commands for UAV operations[23]. Through this connection, the GUI gains the capability to remotely activate Mavros functionalities and plan UAV trajectories within the warehouse space. This SSH integration enhances the system's flexibility, enabling efficient management and coordination of Unmanned Aircraft tasks through a centralized graphical interface[24].

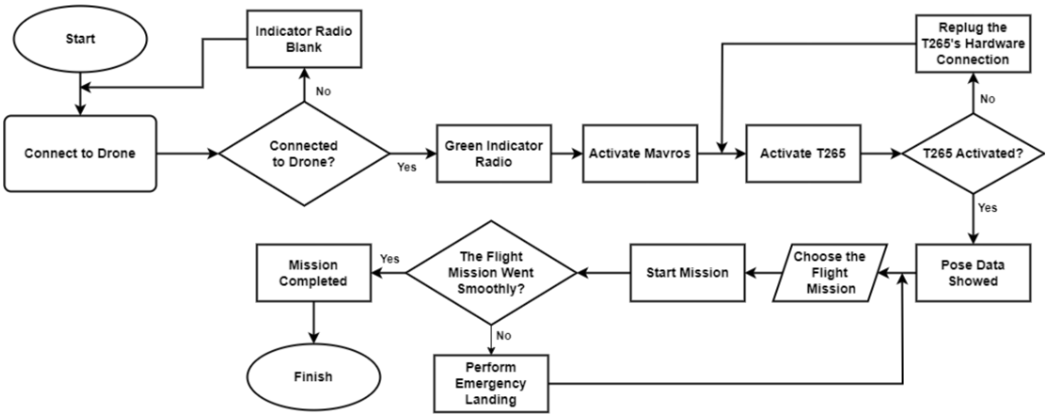

Figure 3. Comunication and Control System Flowchart

Figure 3 is a visualization of the flight management steps in the warehouse in the user interface. The flow initiation starts with opening the user interface, followed by establishing a connection between the user PC and the Unmanned Aircraft. After successfully connecting, the next step is to enable Mavros so that the nodes of the unmanned aircraft can be published by the server device. Next, the camera is turned on to obtain data that is essential in determining the location of the Unmanned Aircraft, or what is commonly referred to as the localization process. If all the previous steps are successfully completed, the user can take an active role in planning the flight path to carry out the desired inventory task.

In an operational context, users are expected to conduct continuous monitoring during flight. In the event of a fault or failure, users should be prepared to take emergency landing measures to ensure the safety and security of Unmanned Aircraft operations.

2.4 Data Management

In the development of this graphical user interface system so that inventory data can be stored and processed by users after the UAV does inventory work, the data storage method used is a database system. Database is a structured collection and storage of data that provides a data storage and management system. This data structure can be operated through a database management system (DBMS) where the user or admin of the database can operate, store, analyze and send data freely and completely[25]. SQL is one of the commonly used Database Management Systems and is open source and flexible on the application of all platforms, SQL is designed to be able to perform extensive data management operations with its own language, namely the SQL language[26].

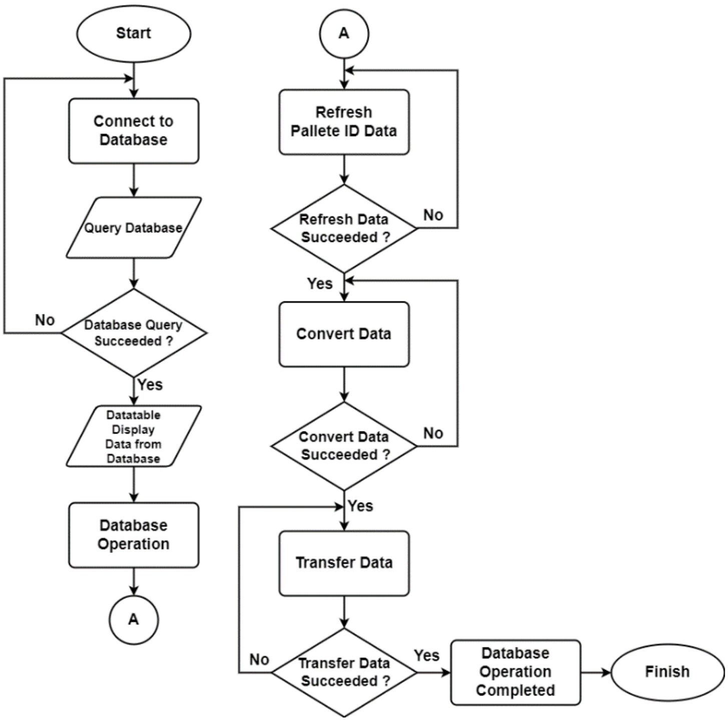

Figure 4. Data Management System Flowchart

Figure 4 displays the flow diagram of the database system applied to the graphical user interface, it can be seen that before the graphical user interface displays the database display, a connection must be made to the database so that the application can connect directly to the database, then query the database to extract the data table available in the database then if the database query process is successful the data can be displayed on the graphical user interface.

3. RESULTS AND DISCUSSION

3.1. Testing Method

The testing method on the PyQt5 GUI is divided into two main focuses, namely testing on the unmanned aircraft control page and testing on the RFID data processing page. Each test is carried out to ensure the function and performance of each interface feature properly.

Unmanned Aircraft Control Page Testing

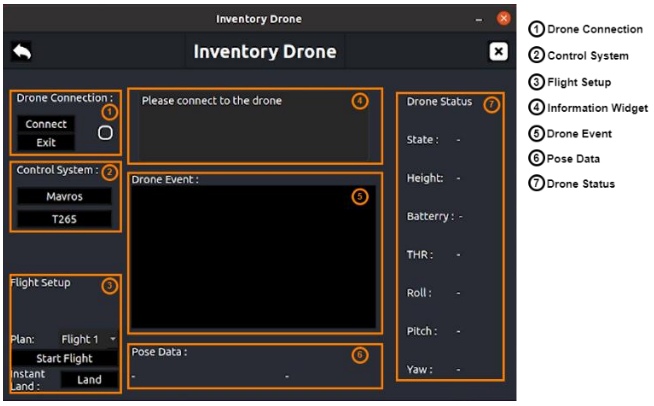

Figure 5. Unmanned Aircraft Control Page

The evaluation of the Unmanned Aircraft Control Page, as depicted in Figure 5, involves a meticulous examination of each element to ensure seamless functionality and reliability.In addressing the first aspect, the Unmanned Aircraft Connection, the assessment centers around scrutinizing the operational capability of the SSH initiation button. This is to ensure a secure connection to the mini PC of the Unmanned Aircraft, with a particular focus on verifying the stability of the established connection.Transitioning to the Control System, the evaluation focuses on the button designed to activate MAVROS and the Intel RealSense T265 camera. This is crucial for Unmanned Aircraft localization. The testing process includes verifying the smooth initiation of these components and ensuring their proper termination.

The examination of Flight Setup encompasses the functionality of the ComboBox, which is crucial for selecting the Unmanned Aircraft's flight mission. Additionally, the assessment confirms the "Start Flight" button's capability to execute the chosen mission and ensures the proper functioning of the "Emergency Landing" button.Turning attention to the Widget Information, the evaluation ensures that the widget offers clear and accurate guidance to users. The responsiveness of the widget is specifically tested to provide information relevant to the ongoing stage of application use.

Within the scope of Unmanned Aircraft Event, testing revolves around the readability and responsiveness of messages issued by MAVROS. This involves verifying the clear display of error messages in case of Unmanned Aircraft problems.In terms of Pose Data, the interface's capability to accurately display Unmanned Aircraft position information (x, y) from the Intel RealSense camera is scrutinized. Additionally, the monitoring function for pose data is tested to detect any abnormalities.Lastly, the examination of Unmanned Aircraft Status ensures the precise display of crucial data such as mode, altitude, battery status, throttle, and movement data (roll, pitch, yaw). The real-time monitoring capabilities for the Unmanned Aircraft's vital data are thoroughly tested.

This structured testing approach, organized according to numbered categories, aims to validate each specific element within the Unmanned Aircraft Control Page. The clarity provided by this approach contributes to the overall reliability and effectiveness of the system.

Data Management Page Testing

Testing on the RFID data processing page is carried out to evaluate the performance and functionality of each feature contained in this interface. The test details are as follows:

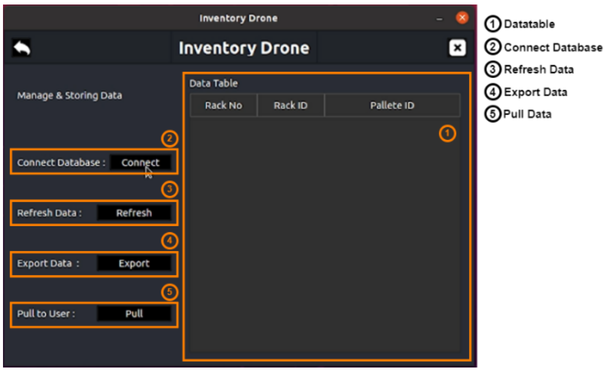

Figure 6. Unmanned Aircraft Data Management Page

Within Figure 6, the Unmanned Aircraft Data Management Page undergoes meticulous testing to validate the functionality and reliability of each element within the interface.Beginning with the assessment of the Datatable, the focus lies on the presentation of data, encompassing rack_id (warehouse rack ID) and pallete_id (warehouse item ID) structures. The evaluation emphasizes the readability and correlation of the displayed data, ensuring precision and coherence.

Moving forward to the Data Management Button Connect, scrutiny is directed towards the "Connect" button's capability to initiate a connection action to the database. The paramount goal is to guarantee the successful initiation of the database connection, a critical factor for seamless data management.The subsequent evaluation pertains to the Data Management – Refresh Data Button. This entails an examination of the "Refresh Data" button's functionality, tasked with clearing the pallete_id structure in preparation for the next day's scan. The assessment validates the successful clearance of data, assuring a clean slate for subsequent scans.

The scrutiny then extends to the Data Management Export Data Button. Here, the focus is on examining the "Export Data" button's prowess in exporting data from the database. The evaluation encompasses testing export functionality both before scanning and after refreshing the data, with additional verification for adherence to the CSV file format standard.The comprehensive evaluation concludes with an assessment of the Data Management - Pull Data button. This functionality involves pulling exported data from the database on the Unmanned Aircraft mini PC to the user device. The testing process ensures the seamless transfer of data from the mini PC to the user device, completing the data management cycle.

3.2 Feature Testing Result

Test Results: UAV Control Page Feature

The primary objective of the evaluation was to assess the functionality and reliability of each element within the interface, ensuring their seamless performance across various scenarios. The testing process covered critical features such as Unmanned Aircraft connection, MAVROS system activation, flight setup, and real-time monitoring of the Unmanned Aircraft status. Each step of the test is designed to comprehensively evaluate the functionality and performance of the interface. The results of the tests conducted are shown in figure 7 below, the figure shows the results of testing the control page features.

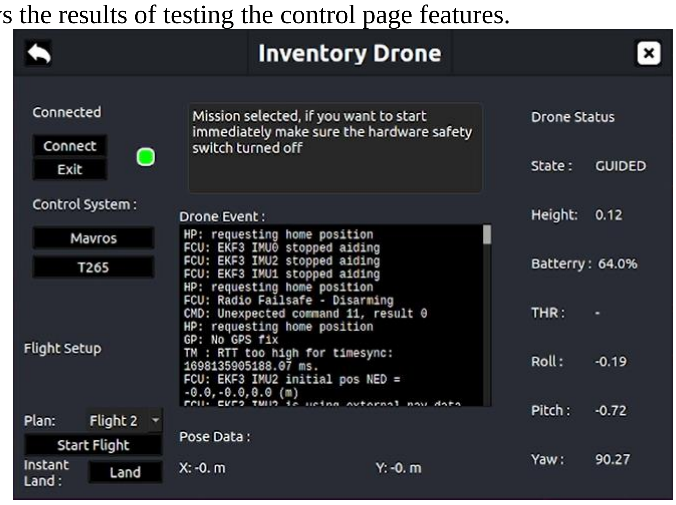

Figure 7. Control page each feature results

In the evaluation of the Unmanned Aircraft Connection, the focus was on verifying the functionality of the button initiating a connection to the Unmanned Aircraft via SSH. The test results indicated a successful and stable connection, moving to the Control System, the evaluation aimed to assess the button's ability to activate MAVROS and the Intel RealSense T265 camera for Unmanned Aircraft localization. The results demonstrated seamless activation and correct termination, with mavros activation data being displayed in Unmanned Aircraft event and T265 activation data in pose data.The examination of Flight Setup involved checking the ComboBox function for selecting the Unmanned Aircraft's flight mission. The "Start Flight" button executed the selected mission, and the "Emergency Landing" button functioned correctly, ensuring the interface's reliability during critical flight operations.

For Widget Information, the objective was to ensure the widget provided accurate instructions to the user. The widget demonstrated its effectiveness by delivering appropriate information corresponding to the application's stage, testing the Unmanned Aircraft Event involved assessing the readability and responsiveness of messages issued by MAVROS. The results confirmed that error messages were clearly displayed in case of Unmanned Aircraft problems, the verification of Pose Data aimed to ensure the interface's ability to display Unmanned Aircraft position information generated from the Intel RealSense camera. Lastly, for Unmanned Aircraft Status, the objective was to ensure that status data were accurately displayed in real-time. The interface effectively monitored crucial Unmanned Aircraft data

This comprehensive evaluation provides a thorough understanding of the interface's performance, confirming its capabilities and functionality across a wide range of operational features. The results are a testament to the thorough testing and validation performed on each element in the control page.

Test Results: Data Management Page Feature

In this section, an analysis of the results obtained from testing the features on the Data Management page is presented. The primary objective is to furnish a detailed examination of each feature's functionality and performance, complemented by visually illustrative screenshots and concise descriptions.

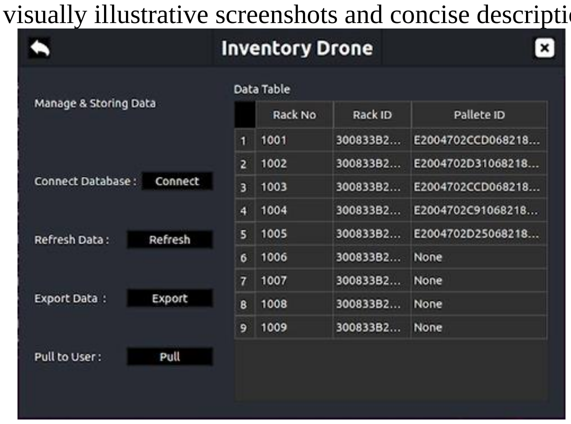

Figure 8. Data Management page each feature test result

Figure 8 above displays the management data page that has been tested for several features, Starting with the evaluation of the Datatable, the focus was on validating the display of data, including rack_id (warehouse rack ID) and pallete_id (warehouse item ID) structures. The results indicate that the datatable effectively showcases structured data, contributing to the clarity of warehouse inventory information. Moving to the Data Management - Button Connect, the evaluation aimed to assess the "Connect" button's ability to initiate a connection action to the database. The results affirm that the "Connect" button successfully establishes a connection to the database, ensuring seamless data retrieval.

The assessment of the Refresh Data Button involved evaluating the functionality of the "Refresh Data" button to clear the pallete_id structure in preparation for the next day's scan. The results demonstrate that the "Refresh Data" button effectively resets data, preparing the system for the next scanning cycle.In the case of the Export Data feature, the objective was to examine its ability to export data from the database. The results confirm that the "Export Data" button successfully exports data in CSV format both before scanning and after refreshing data. Lastly, the evaluation of the Data Management - Pull Data Button aimed to assess its functionality in pulling exported data from the database on the Unmanned Aircraft mini PC to the user device. The results indicate that the "Pull Data" button seamlessly transfers data from the mini PC to the user device, ensuring data accessibility.

3.3 Efficiency Comparison of Using GUI Towards Using Conventional Methods

This study investigates UAV flight preparation efficiency, specifically designed for inventory tasks, by comparing the use of a graphical user interface (GUI) with conventional methods. The conventional methods refer to previous approaches involving repetitive drone connections and sequential program execution through several terminal processes before adopting GUI. The primary emphasis is on assessing the time required for flight preparation, measured in seconds, using widely accepted statistical methods. In the experiment, a total of 30 trials were conducted for each method. The measurement begins by determining the duration from opening either the GUI or conventional terminal to initiating the flight mission, the time was recorded using a stopwatch. Activities such as activating the flight requirements system, selecting a route, and configuring the system were included in the process. The comparison specifically examines the time needed for flight preparation between GUI and conventional methods.

Flight Preparation Time Results

This section reveals the time needed for flight preparation, as shown in Table 2 below. With 30 Data samples each methods (n_1, n_2) the table presents the preparation time for flights using the conventional method represented by X_1, and the GUI usage represented by X_2. A series of 30 trials were conducted to analyze and compare the flight preparation times between these two methods.

Table 2. Flight Preparation Times Data

Flight Preparation Data				
Iteration	X_1 Time (Second)	X_2 Time (Second)	Time Difference	Percentage Difference
1	182	46	136	75%
2	171	51	120	70%
3	183	45	138	75%
4	177	49	128	72%
5	196	50	146	74%
6	188	46	142	76%
7	192	47	145	76%
8	201	49	152	76%
9	189	54	135	71%
10	197	57	140	71%
11	172	48	124	72%
12	190	44	146	77%
13	194	46	148	76%
14	193	46	147	76%
15	186	50	136	73%
16	197	48	149	76%
17	181	55	126	70%
18	192	46	146	76%
19	194	53	141	73%
20	177	48	129	73%
21	175	52	123	70%
22	181	48	133	73%
23	177	50	127	72%
24	171	44	127	74%
25	198	52	146	74%
26	183	49	134	73%
27	190	56	134	71%
28	177	45	132	75%
29	175	44	131	75%
30	189	52	137	72%
Mean	185.6	49	136.6	74%

This section examines the efficiency of a graphical user interface (GUI) in reducing flight preparation time compared to conventional methods. Numerical data shows an average time reduction of 74% with the use of the GUI on the 30 data samples obtained. The GUI was consistently able to reduce flight preparation time compared to the conventional method previously performed. The variation in the time difference during the iterations is mainly due to the diverse hardware and network conditions that impact the performance of the GUI. Meanwhile, in the conventional method, the difference was more related to the user's understanding of SSH, MAVROS, and operation system.

Statistical Test Using Independent Samples T-Test

To support the efficiency of the GUI in flight preparation time, an independent sample t-test was conducted to test and compare the means of the two data groups. The data groups being tested are independent, which indicates that the two data samples are not interdependent or influencing each other between the two categories of data samples, so this test is suitable for looking at the statistical average difference in preparation time between the two methods.

$$H_0: \mu X_2 = \mu X_1 \tag{1}$$

$$H_a: \mu X_2 \neq \mu X_1 \tag{2}$$

The initial approach of this statistical test is to set the parameters of the hypothesis in order to have a reference for drawing conclusions after the test is conducted. The null hypothesis (H_0) states that there is no significant difference in UAV flight preparation time between the GUI and conventional approaches. In contrast, the alternative hypothesis (H_a) showed significant differences in favor of using the GUI. These hypothesis become the basis for a focused examination, using independent sample t-tests to empirically validate the efficiency claims.

(Data Variance / Deviation Standard)

$$S_1 = \sqrt{\frac{\sum_{i=1}^{30}(X_{1i}-\bar{X}_1)^2}{n_1-1}} = \sqrt{79.4897} = 8.9157 \tag{3}$$

$$S_2 = \sqrt{\frac{\sum_{i=1}^{30}(X_{2i}-\bar{X}_2)^2}{n_2-1}} = \sqrt{13.241} = 3.6389 \tag{4}$$

In conducting this examination the primary step involved computing the means of the two relevant data sample groups. The GUI utilization yields an average preparation time of 49 seconds, with a data variance of approximately 3.6389 seconds and a sample size of 30 trials. On the other hand, the conventional method demonstrates an average preparation time of about 185.6 seconds, a data variance of roughly 8.9157 seconds, and an equivalent sample size of 30 trials.

$$t_{value} = \frac{(\bar{X}_1-\bar{X}_2)}{\sqrt{\frac{s_1^2}{n_1}+\frac{s_2^2}{n_2}}} = \frac{(185.6-49)}{\sqrt{\frac{8.9157^2}{30}+\frac{3.6389^2}{30}}} = \frac{136.6}{\sqrt{3.09}} = 77.7 \tag{5}$$

$$df = n_1 + n_2 - 2 = 30 + 30 - 2 = 58 \tag{6}$$

Upon performing the calculation, the obtained t-statistic is $t = 77.7$ with degrees of freedom approximately $df = 58$. Decision criteria involve comparing the absolute t-statistic to the critical value at a significance level (α) of 0.05 was chosen because it is a parameter value that is generally accepted in statistical methods as an acceptable threshold for making statistical decisions. At a significance level of 0.05, it can measure the risk of type I error, which is rejecting the null hypothesis that is actually true. In the context of this study, this risk is considered acceptable, and the choice of this significance level provides a good balance between making critical decisions and minimizing the risk of misinterpretation.

$$t_{critical} = \pm t_{\frac{\alpha}{2}}, df = \pm 2.0017 \tag{7}$$

$$t_{value}(77.7) > t_{critical}(2.0017) = Hypotesis\ null\ (H_0)\ Rejected \tag{8}$$

With the t-critical value obtained from the parameterized t table value obtained based on significant values and degrees of freedom is 2,0017. The critical t value can be compared with the t value in order to obtain the withdrawal of one of the specified hypotheses. The critical t value obtained is significantly less than the t value resulting in the rejection of the null hypothesis(H_0), therefore the alternative hypothesis (H_a) is drawn as a result of this statistical test, indicating a significant difference in average preparation time between the use of the GUI and the conventional method. The consistently shorter duration required by the GUI method reinforces its efficiency in the context of drone flight planning for inventory tasks. These findings have practical implications for improving operational efficiency in the use of UAVs for inventory purposes.

4. CONCLUSION

The GUI designed for unmanned aircraft control and Inventory data processing has proven its usability and efficiency through comprehensive testing. The unmanned aircraft control page successfully underwent rigorous testing of key features, ensuring robust functionality in Unmanned Aircraft connection, required system activation, flight settings, and real-time monitoring. The Inventory data processing page demonstrated effective data display and database interaction, as well as working inventory data management operations for data processing. Efficiency comparison data between the GUI and conventional methods show that the use of the GUI consistently reduces the time required for flight preparation, the time reduction obtained is up to 74% when using the GUI. Statistical analysis was also conducted to support the data on the efficiency of using the GUI using an independent sample t-test. This statistical test showed that the t-critical was less than calculated t-value, resulting in the rejection of the null hypothesis (H_0).These findings provide empirical support for the effectiveness and efficiency of the GUI, positioning the system for practical application. The implications extend to potential improvements in operational efficiency for UAV-assisted inventory management. This GUI system still has many limitations for heavy-duty processes and wider implementation, hence the need for further research for the development of future inventory work systems.

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